

## Automated traffic light system for road user's safety in two lane road construction sites

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**Abstract:** - The road construction safety traffic light system is designed to replace a manual traffic control on a road construction sites. This device can replace one or both flaggers during the two lane closures on the event of a road construction. The road construction safety traffic light system is considered one of the best devices in work zone traffic flow control systems. The device is a portable traffic light unit which can be best utilized in controlling traffic flow in a road construction site for long term or short term lane closures and to control two-way traffic in a single lane. By implementing new technologies in automating traffic flow in road construction site could possibly eliminate the usage of a conventional flagman at all times. The road construction safety traffic light system is a practical solution to solve problems which contribute towards hazards at road construction site and to be inline with the road safety regulation which is taken into granted by the contractors. The automated portable traffic light system can reduce direct costs in man power utilization and increase safety for the road users and construction workers by eliminating the need for a human flagmen. This system is applicable for public and privately funded road construction projects that require overnight or 24-hour traffic control as well as in different weather conditions.

**Key-Words:** - Intelligent traffic light system, programmable logic controller, smart control application, flagman, traffic light

### 1 Introduction to road construction site and accidents

Traffic accidents [1,2] in road construction site are continuing problem in many countries around the world. Safety regulation is revised by responsible authorities periodically in the effort towards a safer working environment on a typical road construction site. The prime concern in a road construction site is the safety of the road users and construction workers.

According to acts as stated in the road construction safety regulation, sufficient safety measures have been always considered in all means especially involving human lives. Statistics on road

construction accidents which was published by Department of Safety, Occupancy and Health (DOSH), highlights indispensable measures which have been overlooked by the appointed road contractors [3]. Ignorance of the road safety regulation has results in various fatal accidents for both domestic road users and construction workers within the road construction site [4].

In the effort to maintain safety and smoothness in traffic flow on the road construction site, the usage of a traffic controller or so called as the flagman is essential [7, 8]. Such practice was introduced edges ago and since then it is widely in practice throughout the world.

The best practice in neutralizing the traffic flow is indirectly position the flagman's life into the fatal zone. Unrealisingly contractors have put the flagman's life in high risk where incidents shows most fatal cases are among them.

The ultimate aim of this research is to implement technological approach which will overwrite the conventional flagman practice. Revolution and modernization have introduced new technologies in assisting and ease human life in various ways. In order to reduce fatalities and injuries from crashes in work zone and to enhance smoothness in traffic operation as well as to ensure safety within work zones, an intelligent traffic light is essential [9].

## 2 Safety regulations on a road construction site

There are various safety measures taken by the responsible authorities in ensuring and reduce the safety of both the road users and the construction workers on a road construction site. As the safety regulation is enforced for the safety of human life's involve in a road construction site, many people take it easy without knowing the consequences. When details analysis is carried out the factors can be listed from each parties who are responsible to these unwanted accidents.

### 2.1 Road Contractors

Most of the contractors are less competent and they do not obey the road safety regulations during construction. These regulations are created by responsible authorities and agencies such as The Department of Occupational Safety and Health (DOSH) which contains legal requirements to ensure safety of the workers at work zone and public. Besides that, there are certain contractors who neglect the rules which are listed by the Ministry of Works.

According to the Ministry of Works, during a road construction there should be a minimum of 10 safety alert sign boards that must be placed on specific locations at the construction area. In most cases the contractors overlook the safety regulations and take it for granted. Indirectly, this irresponsible attitude causes problem to numerous parties.

Apart from that, a flagman who is appointed by the contractors might not be well trained by their employment. These untrained flagmen could be harmful for the road users and themselves. At times the flagman's concentration on controlling the traffic flow also can result in various miseries not only to his life but also to the public. For an example, when the flagman works under the hot sun, they get tired easily and lose their concentration on work.

A flagman disobeying his duty and to neglect the safety rules and standards on a road construction site is shown in Fig. 1



**Fig. 1: Flagman disobeying the safety rules**

The safety warning signs which is a requirement set by Ministry of Works on a road construction site is shown in Fig. 2



**Fig. 2: A road construction site warning sign boards**

Nevertheless, miscommunications also occur when these flagmen uses improper method to communicate among themselves in order to control the traffic [4].

## 2.2 Road user

According to the statistic published by DOSH, shows that reckless road users are the main cause of an accident on a road construction site. Usually flagman who direct traffic around a road construction site are highly visible in their bright orange vests, as they hold up their "Stop" and "Go" signs or their flags to inform drivers what they must do to get through a single lane bypass. Some reckless driver tends to ignore these directions and causes accidents.

In many countries, disobeying the flagman and speeding in road construction sites is serious a punishable which is finable or imprisonment if it results in a bodily injury accident. Other than that, when knowledgeable driver enters a bypass lane, they know the pavement may not be as smooth as the expressway. In fact, it is likely to be rough and uneven, possibly full of potholes and also muddy and slippery.

Fig. 3 shows one scenario of the road construction sites which are typical dangerous for all the road users without a flagman to control the traffic flow.



**Fig. 3: Two lane road construction site without a flagman to control the safety and smoothness of the traffic flow**

The good driver enters the bypass slowly and carefully. But when the irresponsible drivers enter the bypass at higher speed than as posted speed

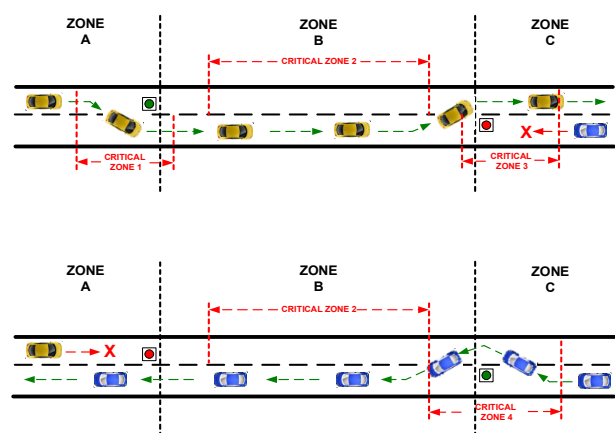
limits, it could cause loss of control of their vehicles. This irresponsible attitude will drift the construction workers and other road user into fatal zone.

Drivers must comply with traffic regulations, as well as security and safety standards for their own safety, other road users' safety and road construction workers' safety as well [4]. Fig. 4 shows another scenario of the road construction sites which are typical dangerous for all the road users without a flagman.



**Fig. 4: Two lane road construction site where the construction works is done in the presence of users**

## 3 Critical zones in a two lane road construction site



**Fig. 5: Two lane road construction view**

Referring to Fig. 5, the risk factor for both the

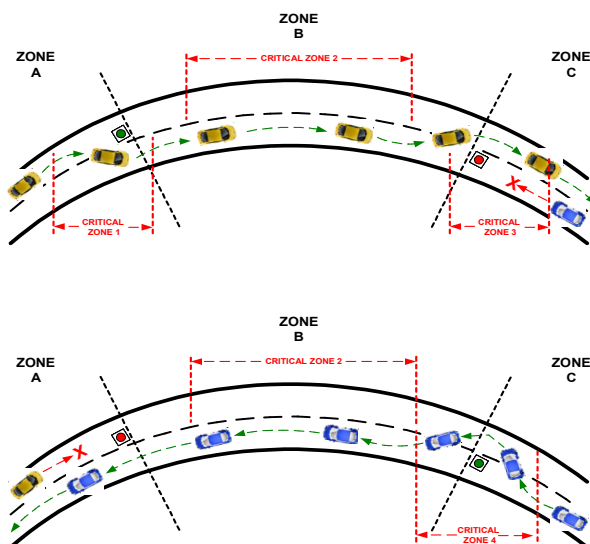


public users and the flagman is high in zone A and zone C. This zone is defined as a critical or high risk zone due to the stopping point of the oncoming vehicles before entering the road construction site. The risk factor here involves the road users and also the traffic controller which is the flagman. The next zone is zone B where the construction or road maintenance job is in operation. The risk in this zone is moderate if the work zone is not close to the road allocated for the users. The contractor should study on possible space for all types of vehicles to pass thru all zones especially between zones as shown in Fig. 5 [10]. A road construction site can be categorized into zones and risk level as shown in Table 1.

**Table 1: Critical zones and risk level in two lane road construction site**

Zones	Scenario 1	Scenario 2
A	HIGH	HIGH
B	MODERATE	MODERATE
C	HIGH	HIGH

There are many types of road construction site and possible danger if safety measures are not taken into account [10, 11]. Fig. 6 shows another scenario of a road structure which is similar to the scenario in Fig. 5 [10].



**Fig. 6: Two lane U shape road construction view**

The risk factor for both the public users and the flagman is high in zone A and zone C. This zone is defined as a critical or high risk zone due to the

stopping point of the oncoming vehicles. The risk factor here involves the road users and also the traffic controller which is the flagman. The next zone is zone B where the construction or road maintenance job is done. The risk in this zone is moderate if the work zone is not close to the road allocated for the users. The contractor should study on possible space for all types of vehicles to pass thru all zones especially between zones. The risk level for this scenario is as shown in Table 2.

**Table 2: Critical zones and risk level in two lane U shape road construction site**

Zones	Scenario 1	Scenario 2
A	HIGH	HIGH
B	MODERATE	MODERATE
C	HIGH	HIGH

#### 4 The road construction site safety traffic light system

The road construction safety traffic light system is designed to be an intelligent system for smooth traffic operation in a typical road construction site with high frequency of vehicles. The automated system which operates without human intervention at all time regardless of weather conditions enables the system to work efficiently for long working durations. The system has many features which empowers the users on dangers at a road construction site. The automatic vehicle presence detection and control system enables the road users to be informed on the traffic flow ahead.

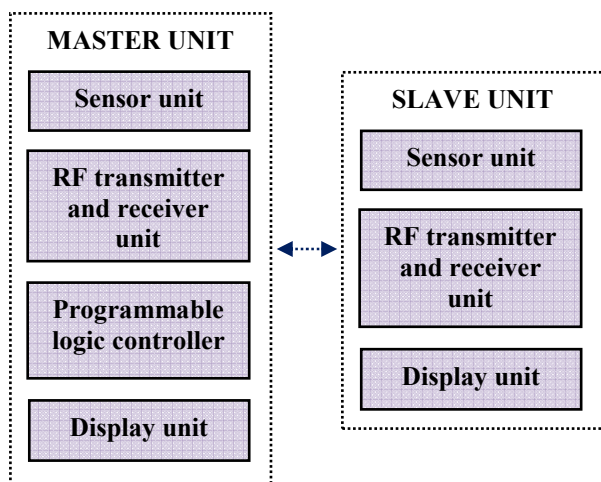
Traffic flow control in a road construction site is difficult to be monitored and controlled in both directions especially during rainy seasons. The intelligent construction safety traffic light system can be best placed at high traffic frequency locations for effective, safe and in ensuring smoothness in the traffic flow in a dangerous road construction site.

The most important factor in a road construction site is the hazard warning sign for the road users. If a system is capable to indicate the road users without human intervention and regardless of weather, it will help the contractors and their workers doing their work without worries.

The intelligent construction safety traffic light

system consists of a number of components working together to perform simple repetitive task [12]. The basic system requires motion detection sensors to detect the presence of vehicles on road construction site, a control unit to process the information and to establish communication between the master and slave unit [12].

The basic structure of the intelligent construction safety traffic light system is shown in Fig. 7.



**Fig. 7: Structure of the intelligent construction traffic light system**

## 5 Advantages of the road construction safety traffic light system

The road construction safety traffic light system is designed based on environmental factors on the road construction site and limitations of a flagman. The device could be one of the best practice in road construction traffic control systems.

The designed device is to replace the conventional flagman who is required during the lane closures on a certain construction zone. Since the designed device is a portable traffic light and best to be utilized in temporary traffic flow control for long term or short term lane closures on construction sites. The device is suitable to control two-way traffic flow in a single lane [9] road construction sites.

The device can be used in publicly and privately-funded road construction projects which require overnight or 24-hour traffic flow control

operations regardless of weather condition. The device is also cost efficient and less compared to the invested cost in the long run.

Some of the main factors which contribute towards the down fall of a flagman compared to the intelligent construction safety traffic light system is shown in Table 3 [9].

**Table 3. Comparison between flagman and the road construction safety traffic light system**

Factors	Flagman	Road construction traffic light system
Working hours	limited	unlimited
Weather condition	not reliable	reliable
Effectiveness	vary	consistence
Fatal Risk	High	Low

The road construction safety traffic light system can be best utilized by road construction site contractors and for any temporary traffic flow control. The system can replace the use of humans in any kind of traffic flow control operation [9].

## 6 Technology behind the road construction safety traffic light system

The road construction safety traffic light system has a number of individual components working together to perform as it is designed. As the construction safety traffic light system is an automated device, the system requires sensors to communicate with the control unit for relevant control functions.

Apart from the sensors, the communication medium for the construction safety traffic light system is using Radio Frequency (RF) as the means for low cost and efficient wireless communication between the master and slave unit. The intelligent construction safety traffic light system is capable to perform the entire process without human intervention.

The road construction safety traffic light system

consists of two main components which is connected one another wirelessly via RF. The master control unit can be placed in a distance away from the slave unit in a certain road construction site.

### 6.1 Sensor unit

There are two types of sensors used to enable the intelligent construction safety light system to operate without human intervention at all times. The system uses infra red detection and motion detection system at both units of the traffic light unit. Both traffic light units are connected via wireless. The wireless unit is designed to be located in each traffic light unit which is capable to communicate within 100 meters in radius.

The motion detection sensors will be used to detect the presence of vehicle at one or both end of the construction site. The detection is approximately 6 meters from the traffic light unit. The detection signal will be used to indicate to the control unit on which end of the construction site has high priority for the users.

Vehicles passing each traffic light unit will be counted using an infra red sensor. The total number of cars passing each traffic light unit will be temporary saved in the control unit and being compared with the another end to make sure all the vehicles are out before the transition of the traffic light changed.

### 6.2 Programmable logic controller

A programmable logic controller (PLC) is used in the intelligent construction safety traffic light system is as shown in Fig. 7. The PLC is an intelligence device which is capable to work without human interventions at all times regardless of duration and weather conditions [5, 6].

The PLC will be placed in the master unit for all the control operations. The wireless circuit is used to generate inputs to the PLC as changes are detected in the sensors. As programmed the PLC will trigger the light indicators at each end of the construction site via wireless. The number of traffic light is integrated based on the number of junction on the road construction site. The system only requires one master controller and others can act as the slave unit for the entire operation.

## 7 Usefulness of the road construction safety traffic light system

The flagman is to be replaced by the road construction safety traffic light system during the lane closures on a certain construction zone [7].

The system is designed to be a portable traffic light and best to be utilized in temporary traffic control for long term or short term lane closures on construction sites, it is suitable to control two-way traffic in a single lane [8].

Fig. 8 shows the conventional system utilizing a flagman during a lane closure to control the traffic flow.



**Fig. 8: Flagman is still a popular practice in a road construction site**

There are many other means of ways to control and to maintain the efficiency of the traffic flow in a certain road construction site. Apart from the conventional practice, automated flagman is now a popular device in ensuring road users safety [13 - 15].

The automated flagman is very common now days in most of the road construction site since they are easy to handle and be able to operate for long hours regardless of weather conditions. Apart from that they are efficient in operation since there are no human factors involved in the indication process [13 - 15].

The automated flagman is shown in Fig. 9 is one of the common flaggers used at most road construction sites as a warning indicators to the road users.



**Fig. 9: Automated flagman in a road construction site**

The intelligent construction traffic light system is empowered by all the factors towards the downfall of the existing system and method used in ensuring the smoothness of traffic flow in a certain road construction site. The system can be used in publicly and privately-funded road construction projects which require overnight or 24-hour traffic control regardless of weather conditions. The system is also less compare to the invested cost in the long run.

The factor which is contributing towards the down fall of a flagman compare to the intelligent construction safety traffic light system is shown in Table 4 [9].

**Table 4. Comparison between Flagman and Intelligent Traffic Light System**

Factors	Flagman	Intelligent traffic light system
Working hours	Limited	unlimited
Weather condition	not reliable	reliable
Effectiveness	Vary	consistence
Fatal Risk	High	Low

## 8 Application of the road construction safety traffic light system

There are many possible locations and road construction sites where the utilization of an intelligent construction safety traffic light system is necessary. The wise application of the system would results in various advantages to both the public and road users.

The main application of the system is greatly appreciated in a typical road construction sites where road closure is necessary. There are many types of road construction nature. The road construction could be two way roads, three junction roads and cross junction roads. The number of traffic light used in one system can be modified according to the need. The master control is capable to communicate with more than one unit of slave unit for operation of more than two junctions.

Apart from that, the system could be used for temporary traffic flow control. Temporary traffic flow control usually is done by the traffic police and is not practically during bad weather conditions. In big cities, traffic flow is very high especially during peak hours. The system can also be used for such applications with the hand held control unit.

There are many more practical applications of the intelligent construction safety traffic light system towards mankind [19, 20].

## 9 Conclusion

Flagman plays a major role in ensuring both safety and to control the traffic flow in a road construction site. In the common practice, the flagman is always placed in high risk location on a road construction site. The awareness on safety signs and safety regulations should be complied by both the contractors and the road users as the first step to avoid unwanted accidents to happen [16 - 18]. Appropriate measures should be taken by the responsible authorities in afford to minimized the risk involved to the flagman in a typical road construction site.

Implementation of new technology would be a wise step in ensuring the safety of a flagman and the road users in a road construction site. Visualization on the technology growth has shown



mass changes to the man kind in many ways in their daily life's. The revolution of an safety road construction traffic light system creates a compact solution towards all miseries as highlighted in this research. The implementation of such technology could result in saving thousands of Dollars in damages and the most important factor is to prevent life losses.

Such an approach has been taken in developing the safety road construction traffic light system which is believed to provide a better and safer indication to both the contractor and public. The system emphases on the elimination of a flagman from the conventional practice in many road construction sites. As a road user and also a public conscious researcher in minimizing such miseries, responsible authorities should implement stern punishment to those contractors who fail to comply the road construction safety regulations.

## 10 Acknowledgment

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A. I. Automation Sdn. Bhd.

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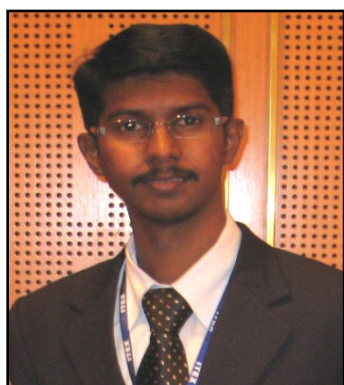
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## 12 Biographies



Siva Kumar Subramaniam was born on 16 July 1981. He received his Diploma of Electronics Engineering from Politeknik Ungku Omar, Malaysia in 2002. He then graduated with a Bachelor Degree in Electronics Engineering (Industrial Electronics) from KUTKM Malaysia in 2006 and his Master studies in Electronics Engineering in the same institution in 2009 which is now known as

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Vigneswara Rao Gannapathy was born on 30 August 1982. He is currently serving as a tutor in the Computer Engineering Department in the Faculty of Electronics and Computer

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Abdul Hamid bin Hamidon @ Hamid Don was born on 3 March 1950. He received his Bachelor of Electrical Engineering from Monash University, Australia and Masters of Science (Electronics) from

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